The EuroBiotech Journal

RESEARCH ARTICLE
Food & Feed Biotechnology

Influence of magnesium gluconate salt addition on mixing, pasting and fermentation properties of dough

Georgiana Gabriela Codină[1], Dumitru Zaharia[2], Sorina Ropciuc[1] and Adriana Dabija[1]

Abstract

The effect of magnesium ions from gluconate salt at the level of 100, 150 and 200 mg/100g addition on empirical dough rheological properties from the 550 wheat flour type was studied. Dough rheological properties during mixing (dough development time, dough stability, degree of softening), α amylase activity and gelatinization temperature were analyzed by using a Falling Number and Amylograph. During fermentation were analyzed the maximum height of gaseous production, total CO_2 volume production, volume of the gas retained in the dough at the end of the test and the retention coefficient by using a Rheofermentograph device. By magnesium gluconate (Mg) salt additition dough become more strength by an increase of stability and a decrease of the degree of softening. With Mg additition wheat flour dough volumes were affected. Compared to the control sample, the dough volume decreased with the increased level of Mg. From the point of view of the α amylase activity, it decreases with the increase level of Mg whereas the gelatinization temperature increases.

[1]Faculty of Food Engineering, "Ştefan cel Mare" University, Suceava, Romania
[2]S. C. Dizing S. R. L. Brusturi, Neamţ, Romania

Corresponding author: G. G. Codină
E-mail: codina@fia.usv.ro

Published online: 20 July 2017
doi:10.24190/ISSN2564-615X/2017/03.04

Introduction

In the human body magnesium has a great importance being the fifth most abundant mineral after potassium, calcium, phosphorus and sodium (1). It participates in the metabolism of carbohydrates, fats, in the growthing process and cell permeability (2). It is a catalytic element and also a plastic one and it is a growth factor, a psychical balancing that help regulate calcium balance in the human body with an anti-aging role, anti-anaphylaxis, anti-atherosclerosis, e.g.

An insufficient magnesium quantity may increase the incidence of degenerative cardiovascular disease, its concentration in the human blood of persons suffer of atherosleros is being inversely proportional correlated with the cholesterol level (3). Also the magnesium deficiency is involved indigestive diseases, kidney problems, allergies, nerve damage, e.g. Due to the fact that many people's has a magnesium deficiency it is a great interest nowadays in enriching some foods with magnesium salts which may help some people health (4). Many people's have been suggested of the fortification of cereal-grain products with magnesium. In the mid-1970s was proposed by the Food and Nutrition board that wheat flour to be enriched with 200 mg/100g flour but this proposal has never been implemented (5).However whole grain products are a good source of magnesium which from the quantity point of view is the most predominant mineral of the grains. But unfortunately most grain products consumed are refined and through the refination process the wheat bran and germ are removed which lowers the magnesium content by 80 percent. That's way the enrichment of refined flour with magnesium is a good alternative to improve the nutritional value of refined wheat grain. However like any food ingredient its addition may affect the technological behaviour of wheat flour dough and therefore bread quality. The bread processors should take into account the changes that occur during mixing, pasting and dough fermentation in order to make the correct adjustment during the bread making process. Impact of magnesium salt addition on wheat flour dough technological process has been previously studied (6, 7, 8). This study want to completely the studies previously made by making a full analysis on effect of magnesium ions from gluconate salt at the level of 100, 150 and 200 mg/100g on dough rheological properties during all the technological process.

Materials and Methods

Materials

Wheat flour of 550 type (harvest 2016) obtained from S.C. Dizing SRL (Brusturi, Neamţ, Romania) were used in this study. According to Romanian or international standard methods the following characteristics were analyzed: moisture content (ICC methods 110/1), ash content (ICC 104/1), protein content (ICC 105/2), wet gluten content (ICC 106/1), gluten deformation index (SR 90:2007), falling number (ICC 107/1). For the wheat flour used in this study were obtained the fallowing results: 14.0% moisture, 0.55% ash, 13.2% protein, 1.4% fat content and 31% wet gluten.

Like magnesium salt an magnesium gluconate ($(CH_2OH(CHOH)_4COO)_2Mg$) were used.

Methods

Dough rheological properties during mixing were made by using an Farinograph device (Brabender with a 300 g capacity) according to ICC method 115/1. The parameters analyzed were the water absorption (WA, %), dough development time (DT), dough stability (ST) and degree of softening (DS) at 10 min. α-amylase activity of the wheat flour with different levels of gluconate salt addition were recorded using a Falling Number device (Perten Instruments, Sweden) according to ICC method 107/1.The wheat flour dough gelatinization properties were made by using an Amylograph (Brabender OGH, Duisburg, Germany) according to ICC method 126/1. The methods measures gelatinization temperature (T_g, °C), peak viscosity (PV_{max}, BU) and temperature at peak viscosity (T_{max}, °C). Dough rheological properties during fermentation were made with a Chopin Rheofermentometer (Chopin Rheo, Villeneuve-La-Garenne Cedex, France) which measures maximum height of gaseous production (H'm, mm), time required to reach H'm (T1, min), time when the dough begins to give of CO2 (Tx, min) total CO_2 volume production (VT, mL), total volume of CO_2 lost (VL, mL), volume of the gas retained in the dough at the end of the test (VR, mL), and retention coefficient (CR, %). These values were the average of three observations. The results of the research were statistically interpreted using the XLSTAT version 2016. They were correlated with the dependent variables studied using the main component analysis at a significance level of 5%.

Results and Discussions

The wheat flour used in this study is of a strong one for bread making. The magnesium ions from magnesium gluconate salt influenced all the Farinograph properties: water absorption, dough development time, stability and degree of softening as it can be seen from the **Table 1**.

It may be noticed that WA decreased with the increase level of magensium ions from gluconate salt addition. This decrease may be due to the gluten structure alteration due to the magnesium ions which enhance the protein dissociation. Similar results were obtained by Sehn (6) andKaur (7).

From the point of view of dough development time this value increased with the increase level of magnesium gluconate salt addition probably due to the fact that in the presence of magnesium ions the protein solubility from the wheat flour decreased allowing to some proteins hydrophobic groups to interact. These results are in agreement with those obtained by Sehn (6) and in disagreement with those obtained by Salovaara (8) which found that by magnesium chloride addition dough development time decreases.

Dough stability increases proportional with the increase level of magnesium concentration the results being similar with the results obtained by Sehn (6) which used magnesium sulfate in their determinations. However different results were obtained by Kaur (7) and Salovaara (8) which obtained a decreased of dough stability by addition of magnesium ions derived from magnesium sulfate and magnesium chloride.

Regarding the DS parameter value it decreases with the increase level of gluconate magnesium salt addition indicating the fact along with the increase value of dough stability that the addition of magnesium ions from the gluconate salt conduct to a strength effect on the wheat flour dough.

In the **Fig. 1** is shown the PCA graph of the Farinograph

Table 1. Effect of effect of magnesium ions from the gluconate salt on Farinograph rheological properties

Magnesium ions addition (mg/100g)	WA (%)	DT (min)	ST (min)	DS (BU)
0	60.0±0.02	6.0±0.01	9.5±0.02	19±0.01
100	59.6±0.03	6.4±0.02	10.3±0.02	17±0.01
150	57.6±0.04	7.8±0.02	13.0±0.01	7±0.01
200	56.5±0.03	9.5±0.03	17.2±0.02	2±0.01

W, the amount of water required to reach a dough consistency of 500 UB; DT, dough development time - the time to reach maximum consistency (min);ST, dough stability - time which dough consistency is kept at 500 BU; DS, degree of softening – the difference between maximum dough consistency and that after 10 minutes.

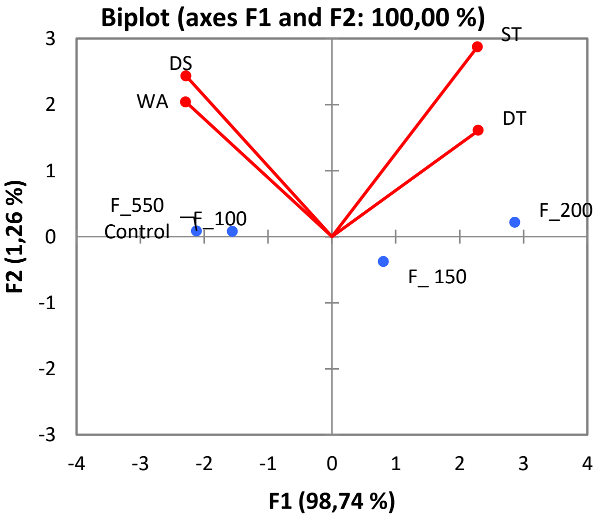

Figure 1. The PCA graph of the Farinograph parameters.

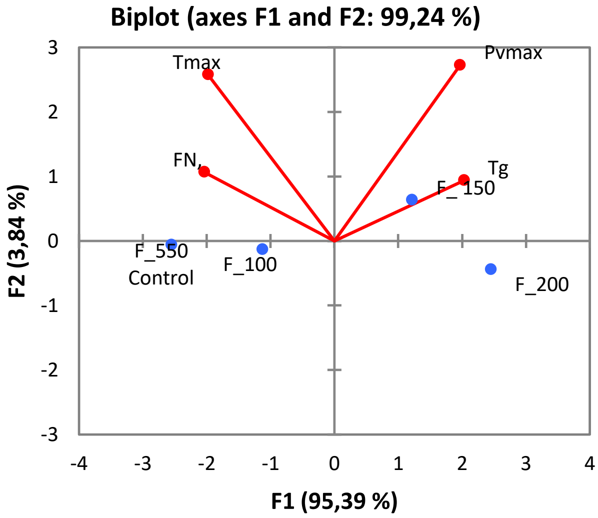

Figure 2. The PCA graph of the Amylograph parameters.

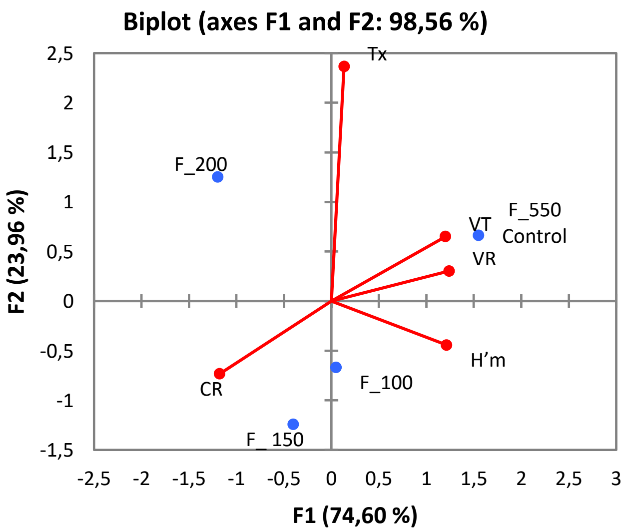

Figure 3. The PCA graph of the Rheofermentograph parameters.

parameters obtained at different levels of magnesium ions from magnesium gluconate salt addition.

The analysis of the main components describing the dough behavior at Farinograph indicates good correlations with the addition of magnesium gluconate, 100 mg / 100g of wheat flour of 550 type. It clearly indicates that it behaviour is more similar with the control sample regarding the water absorption (WA) and degree of softening (DS) to 10 min values. The dough's behavior with the addition of 200 mg / 100g of 550 wheat flour type its very different compared to the control sample reducing the dough water absorption and leading to the increase of dough development and it stability.

Amylograph curve characteristics: gelatinization temperature (T_g, °C), peak viscosity (PV_{max}, BU) and temperature at peak viscosity (T_{max}, °C) significantly different with the mangnesium ions addition. Peak viscosity and gelatinization temperature increases whereas the temperature at peak viscosity decreases. Similar results were obtained by Kaur (7) which explained this behaviour to the suppressed enzymatic activity of the wheat flour dough in the salt presence. This fact is probably true since the falling number value increases by magnesium gluconate salt addition which indicates a decrease level of alpha amylase activity from the dough system.

The alpha amylase activity and wheat flour dough gelatinization properties at different levels of magnesium ions from gluconat salt addition are shown in **Fig. 2**.

The addition of magnesium gluconate in the amount of 150 mg / 100g of wheat flour presented the highest values regarding the gelatinization temperature (Tg) and it peak viscosity (PV_{max}).

During fermentation time all Rheofermentograph parameters are modified as we can see from the **Table 2**.

The Rheofermentograph parameters decreased proportional to the increase in the amount of gluconate salt. This results

Table 2. Effect of effect of magnesium ions from the gluconate salt on Rheofermentograph values

Magnesium ions addition (mg/100g)	H'm (mm)	VT (mL)	VR (mL)	CR (%)
0	68.8±0.01	1479±0.01	1070±0.01	72.3±0.01
100	62.7±0.01	1232±0.02	1024±0.02	83.1±0.02
150	57.3±0.02	1192±0.01	1003±0.01	84.1±0.01
200	50.0±0.01	1169±0.02	991±0.02	84.8±0.02

VT, total CO_2 volume production; H'm maximum height of gaseous production; VR, volume of the gas retained in the dough at the end of the test, CR, retention coefficient.

Table 3. The coorelation matrix between all the Rheofermentograph values

Variables	H'm (mm)	T1 (min)	Tx (min)	VT (mL)	VL (mL)	VR (mL)	CR%
H'm (mm)	**1**	0.489	-0.065	0.861	0.824	0.946	-0.829
T1 (min)	0.489	**1**	0.782	0.672	0.662	0.667	-0.663
Tx (min)	- 0.065	0.782	**1**	0.361	0.395	0.237	-0.390
VT (mL)	0.861	0.672	0.361	**1**	0.997	0.976	-0.998
VL (mL)	0.824	0.662	0.395	0.997	**1**	0.957	-1.000
VR (mL)	0.946	0.667	0.237	0.976	0.957	**1**	-0.960
CR%	- 0.829	- 0.663	-0.390	-0.998	-1.000	- 0.960	**1**

H'm maximum height of gaseous production; T1, time required to reach H'm; Tx,. time when the dough begins to give of CO_2; VT, total CO_2 volume production; VL, total volume of CO_2 lost; VR, volume of the gas retained in the dough at the end of the test; CR, retention coefficient.

indicate an decrease of yeast activity perhaps due to an increase of osmotic pressure by magnesium gluconate salt addition. **Fig. 3** shows the PCA loadings of the Rheofermentograph values.

Dough characteristics during fermentation indicate a positive correlation between the dough height and VR and the volume of the gas retained at the addition the best correlation being obtained for 150 mg of gluconate magnesium addition in wheat flour.

The correlation matrix obtained between al the Rheofermentograh variables are shown in **Table 3**.

It may be seen that good positive correlation were obtained between H'm and VR (r=0.946), between VT and VL (0.997), between VT and VR (r=0.976) and inverse correlation between CR and VT (r=-0.998) and VR (r=-0.960).The good correlation obtained between maximum height of gaseous production and the total CO_2 volume production indicated the fact that by gas production in wheat flour dough, it development is higher. Also the good correlations obtained between total CO_2 volume production and total volume of CO_2 lost and respectively volume of the gas retained in the dough at the end of the test indicated the fact that the higher levels of gas formed in the dough conducted to higher levels of gas loss and higher levels of gas retained. Due to the fact that CR is the retention coefficient of the gas production in the dough system its correlation with VT and VR is quite predictable.

Acknowledgements

This work was supported by a grant of the Romanian National Authority for Scientific Research and Innovation, CNCS/CCCDI – UEFISCDI, project number PN-III-P2-2.1-BG-2016-0079, within PNCDI III.

Conflict of Interest Statement

The authors confirm that this article content has no conflict of interest.

Refrences

1. Oh HE, Deeth HC. Magnesium in milk. International dairy journal 2017; 71:89-97.
2. Volpe SL. Magnesium. In: Present knowledge in nutrition (10th ed.) Erdman JW, Macdonald Jr. IA, Zeisel SH. (Eds.). New York, NY, USA: John Wiley & Sons, Inc 2012; pp. 459-474.
3. Blaszczyk U, Duda-Chodak A. Magnesium: its role in nutrition and carcinogenesis. Rocz Panstw Zakl Hig 2013; 64 (3):165-71.
4. Abrams SA, Atkinson SA. Calcium, magnesium, phosphorus and vitamin D fortification of complementary foods. Journal of Nutrition 2003; 133: 2994-2999.
5. Bock MA. Minor constituients of cereals. In: Handbook of Cereal Science and Technology, Second Edition, Revised and Expanded, Kulp K, Ponte JG. (Eds.). New York, NY, USA: Marcel Dekker 2000; pp. 485-487.
6. Sehn GAR, Nogueira AC, Almeida EL, Chang YK, Steel CJ. Fortification of wheat dough with calcium and magnesium ions affects empirical rheological properties. Cereal Chem 2015; 92 (4): 405-410.
7. Kaur A, Bala R, Singh B, Rehal J. Effect of replacement of sodium chloride with mineral salts on rheological characteristics of wheat flour. Am J Food Tech 2011; 6: 674-684.
8. Salovara H. Effect of partial sodium chloride replacement by other salts on wheat dough rheology and bread making. Cereal Chem 1982; 59 (5): 422-426.